

# Current Developments in the Penaeid Shrimp Culture Industry

BY JAMES P. McVEY, Ph.D.

Rearing commercial shrimp under controlled conditions is becoming more attractive each year. The present U.S. shrimp fishery, one of the most valuable U.S. fisheries with a yearly value approaching half a billion dollars, cannot meet domestic demand. In 1977 approximately one-half of the shrimp consumed in the United States was imported at a cost of another half billion dollars, creating a significant foreign trade deficit. Shrimp consumption is predicted to increase by 33% in the United States and 26% worldwide from 1975 to 1985. The price of shrimp will continue to rise because of increased demand, limited supply, and the escalating cost of fuel. However, many fishery biologists believe that most shrimp stocks are now being fished at their maximum sustained yields and the only way to put more shrimp on the table is through shrimp aquaculture.



*PENAEUS STYLIROSTRIS* brood stock used in captive mating and spawning experiments at National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory.

## Shrimp Farming Throughout the World

Modern shrimp farming had its beginning in Japan in 1933 when Mr. Fujinaga succeeded in spawning the Japanese prawn, *Penaeus japonicus*, in captivity. More than 20 years elapsed before the technical procedures were developed for commercial development to begin in 1964. There are now many Japanese companies producing shrimp for markets in Japan.

Shrimp farming has been occurring for many decades in the Philippines, Indonesia, and Southeast Asia as a consequence of milkfish farming. Shrimp larvae enter milkfish ponds when the tidal gates are opened to initiate the milkfish culture cycle and the shrimp are subsequently harvested along with the milkfish. Certain areas, with good recruitment of wild postlarval shrimp, have developed reputations as consistent producers of pond-reared shrimp, but until recently, there has been little technological development specifically directed at improving shrimp production. There is now a major government program designed to provide shrimp seed stock to private

producers in the Philippines, and many private shrimp hatcheries are in operation to supplement seed supplies. Shrimp production in ponds is increasing steadily and providing additional shrimp for export markets.

The most significant activity in shrimp culture has been in Central and South America. Ecuador leads all Latin American countries in production of shrimp from ponds, with an estimated one-third to one-half (3 - 5 million pounds) of total country production coming from pond-reared shrimp. Panama is rapidly following the lead of Ecuador and is developing new shrimp production ponds at an unprecedented rate which has doubled the production ponds to almost 1,000 hectares in the past year. Costa Rica, Honduras, Guatemala, Colombia, and Brazil are all developing their shrimp culture potential. Many of the companies are financed by United States money, but an increasing number are owned and operated by Latin Americans. At present the technology in Latin America is similar to that of most of Southeast Asia where wild seed stock is captured and placed in ponds, but there is increasing interest and emphasis on developing shrimp hatcheries and captive reproduction to augment the supplies of wild seed stock. This higher technology has been developed primarily by United States companies and research institutions, the French aquaculture program under CNEXO, and Japanese and Taiwanese research efforts. However, only Taiwan and Japan have significant shrimp farming within the country, while France and the United States have practically no commercial shrimp farms.

The lack of shrimp aquaculture development in the United States has been attributed to the lack of a national policy on aquaculture, difficulty in obtaining permits and dedicated land, conflicts with United States environmental and recreational interests, lack of year-round availability of seed stocks, and climatological problems primarily related to temperature. If these obstacles and certain technological problems are solved, we can expect the development of a shrimp culture industry within the United States.

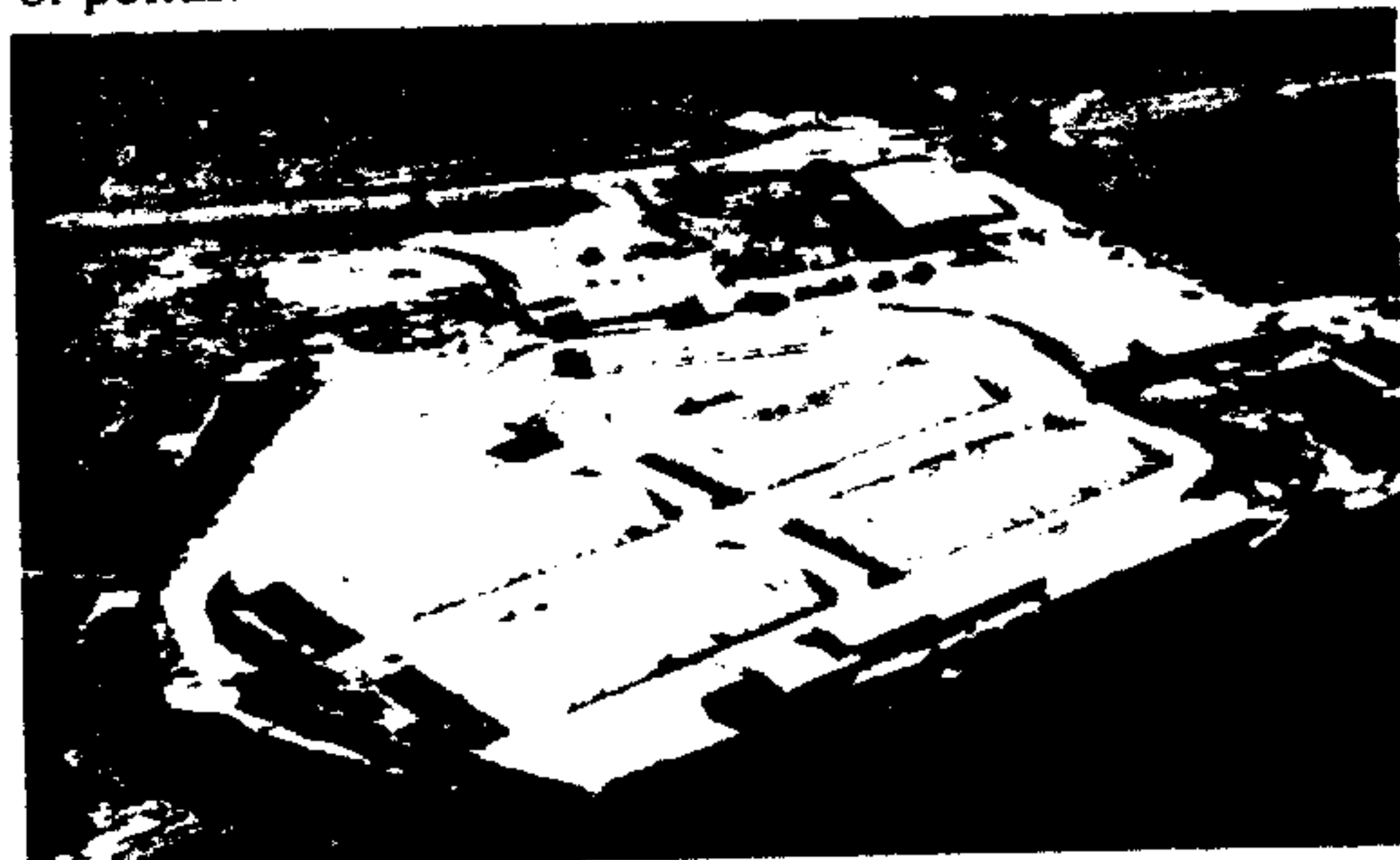
## Current Status of U.S. Commercial Shrimp Aquaculture

Recent technological breakthroughs in obtaining year-round production of shrimp larvae (*Penaeus stylirostris*) through captive reproduction, and advances in hatchery production systems have improved the feasibility of shrimp aquaculture in the United States. Shrimp farming will probably occur along coasts with extended warm weather growing seasons. Two options, intensive culture in raceways or tanks, and extensive culture in ponds, exist for commercial culture, but extensive culture may be limited to areas like Texas with large amounts of uncommitted coastal land. Extensive culture would require 1,000 to 3,000 acres of land for optimum scale, whereas intensive culture could be developed in 5 to 50 acre plots.

Many companies are now considering investments in shrimp aquaculture. The predictions for success or failure vary with the company and with each new technological development or problem.

### Marifarms

Marifarms which began operations in 1968, was the first commercial shrimp farm in the United States and is located in Panama City, Florida. The facility originally consisted of 2,500 acres of bay enclosed with a net to keep out large predators, 650 acres of ponds, and a hatchery sufficient to produce 100,000,000 juvenile shrimp at one time. The net enclosure of the bay was abandoned as impractical in 1978 and production is now limited to the 650 acres of ponds.



AERIAL VIEW of 300 acre pond at Marifarms in Panama City, Florida.

The pioneers of Marifarms, John Chesire and Joe Ikaguchi, have brought the company through many trials and tribulations ranging from loss of the surround nets in the bay due to tropical storms to difficulties in obtaining seed stock in the proper time frame. Both men feel that the shrimp farming industry has worked out most of the technological difficulties that plagued the early industry, but they are very concerned with the difficulties they now face with regulations governing use of wetlands and marsh, conflicts they face with recreational interests for use of the estuary, and the difficulty of obtaining permits for expansion of the production ponds. Marifarms was recently denied a permit to expand their pond capacity by 300 acres and they feel they need this addition to reach the appropriate scale of operations to achieve commercial success. Based on past experience, they feel that extensive pond culture requires 1,000 to 3,000 acres to be commercially successful.

Marifarms is now achieving a reliable production of 500 pounds per acre per year, but they have obtained yields between 700 and 1,000 lbs. per acre. Chesire is convinced that the "industry will see a slow improvement in production with the use of new shrimp species and varieties to 1,500 pounds per acre." However, his immediate goal is to obtain half a million pounds (770 lbs/acre) of shrimp in their present 650 acres of production ponds. Marifarms' present production costs are approximately \$1.20 per pound, but an increase in the scale of production could bring this figure down to 75¢ per pound. This cost prediction is based on the use of *Penaeus vannamei* which has superior production performance. When asked what technological improvement would bring the greatest returns to

the shrimp industry, Chesire said that improvement in feeds and genetics could double production in 25 years. He is particularly excited about the possible use of cryogenics to provide a stockpile of larval shrimp for year-round seed supply.

In summary, Chesire feels that lack of technology had inhibited the shrimp farming industry in the early years, but that governmental regulations and public opinion are now the most serious problems to overcome. "There is a general attitude in the country that people would rather have land dedicated to recreation than production of food. People in the United States have forgotten the farmer and the real strengths of America. Marine farming, rather than being shunned, should be encouraged. Valuable production land along coasts should not be used only for recreation and tourism, but should include space for marine farming operations," he said.

### Coca-Cola/F.H. Prince

A consortium of Coca-Cola Company and F.H. Prince Company, of Chicago, has been supporting research at The University of Arizona (Environmental Research Laboratory) and The University of Sonora, in Mexico, to determine the feasibility of rearing commercial shrimp under controlled environmental conditions in flow-through raceways or troughs. After six years of research, including a pilot-scale one-acre production facility, they are just about to conclude arrangements for a 10-hectare production facility to be placed on the north shore of Oahu, Hawaii.

A new company, Marine Culture Enterprises, located at the Tucson International Airport in Tucson, will oversee the new shrimp culture operations which are expected to expand to other areas of the world if the Hawaii operations are successful. John Carpenter, the president of Marine Culture Enterprises, said that the first production facility in Hawaii should be on line within the next year. The operation will be completely integrated from the production of food for the shrimp to the final shrimp product ready for consumption. According to Carpenter, the Hawaii facility will be in 1 hectare increments and all water production units will be under greenhouse covers for more complete environmental control. The shrimp will be reared in long raceways where the water will be exchanged several times each day. This method of culture requires a complete pelleted diet and considerable research has gone into the perfection of a diet that provides the shrimp with all their nutritional needs. The company expects to produce in the range of 50,000 lbs/acre/year, using *Penaeus stylirostris*, compared to the 1,000 lbs/acre/year projected for extensive pond culture.

Carpenter sees the major problems of the system as the difficulty in obtaining the necessary foodstuffs, high energy costs, and political barriers, depending on locations. He believes that the effluents from the operation will meet all Environmental Protection Agency standards because of the project engineering and, therefore, he does not expect any environmental problems.

Hawaii was selected for the first installation because of the strong governmental support for aquaculture from the State of Hawaii, the suitability of water quality, ambient water temperatures, and excellent logistical location of the selected site.



### Ralston Purina

Ralston Purina has maintained a significant research effort directed at the commercialization of shrimp culture for 6 - 8 years. The company is considered one of the leaders in the industry and is now in the process of expanding production facilities as a result of significant improvements in technology and pond management techniques.

Ralston Purina maintains a research facility at Crystal River, Florida, where efforts are primarily on reproductive and hatchery technology. Their main installation is in Panama, Central America, where there are separate facilities for shrimp reproduction, shrimp hatchery activities, and pond production. The company is concentrating on the culture of *Penaeus vannamei* and *Penaeus stylirostris*. Excellent progress has been made in determining the nutritional and environmental requirements of these species. *Penaeus vannamei* appears to be the species of choice because of its performance under high density conditions, but *Penaeus stylirostris* performs well under some seasonal conditions.

### Aquabiotics, Inc.

Aquabiotics, Inc. is located in Addison, Illinois, and is just beginning operations to culture marine shrimp in closed system intensive culture using artificial seawater. The president, Howard Turney, is optimistic about closed system technology.

At the present time there are 19 biologists on the staff, with plans to enlarge the group by another three biologists by the first of July. Turney said he got interested in shrimp rearing 12 years ago when he began developing the system

and putting investors together to start the venture. Turney explains that he worked on the concept with marine biologist consultants over the years until he got it to the point where the system proved feasible. A year ago he proceeded to hire his own biologists to complete the refinements and the company officially began operations. The company was to have moved to its first production facility, at Park Forest South, Illinois, by July 1. Turney hopes the unit will reach a production level of 50,000 lb/week year-round.

### Commercial Shrimp Culture International (CSCI)

CSCI is located at Port Isabel, Texas, and has been involved in penaeid shrimp culture research for several years. The president, Durwood Dugger, has served as a consultant for the design of shrimp hatcheries in Bangladesh and in Ecuador. The company maintains a small research facility at Port Isabel and the main emphasis is on the development of semi-closed and closed system culture of penaeids. Dugger feels that the shrimp culture industry in the United States will go to closed system culture because of the cost of coastal land, and the need to avoid conflict with recreational use of coastal land.

Dugger stated "the major problem facing the industry today is a mechanism for obtaining commercial loans." He suggests a government pilot project to generate the data necessary to demonstrate the economics so that banks would have sufficient information to evaluate loan requests. He feels Texas is a prime location for extensive culture of shrimp, but all southern coastal land would be suitable for intensive culture operations. When asked what

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contribution shrimp aquaculture could make to United States shrimp supplies, Dugger said that "the United States could be self-sufficient in shrimp by combining domestic wild harvest shrimp and cultured shrimp. The shrimp culture industry would require 250,000 acres of extensive production ponds or approximately 10,000 acres of intensive culture systems (Coca-Cola figures) to equal present United States consumption. Texas has several hundred thousand acres of marginal agricultural land adjacent to estuary systems that would be ideally suited to shrimp aquaculture so it is feasible that all U.S. shrimp requirements could be met from that state alone." Dugger feels that coastal planning must provide for the eventuality of large scale shrimp culture along our coastal lands, or we will have serious conflicts that will reduce our options for economic stability in coastal areas.

### Intensive Culture Systems

Intensive Culture Systems, located at Summerland Key, near Key West, Florida, is a company devoted primarily to the technological development of closed, high density culture of penaeid shrimp. ICS has primarily supplied technical input to Sea Farms Honduras, a United States financed farm in Honduras. ICS' president, Jerome (Jerry) Thompson stated that we will see significant development in intensive culture of penaeid shrimp in the United States within the next five years. He thinks that we can reasonably expect 5 to 10% of United States consumer needs for shrimp to be met by aquaculture and that intensive closed system culture is the best way to go for the United States industry because there will be fewer legal

and environmental constraints.

Technologically, Thompson said that nutrition remains one of the best areas for additional advancement. The intensive culture systems ICS is experimenting with "are now capable of supporting 20 shrimp/ft.<sup>2</sup> (40/lb., 20,000 lbs./acre), but much greater densities are possible with better diets and varieties."

### Solar Aquafarms

Solar Aquafarms is located in Encinitas, California, and specializes in developing intermediate technology for aquaculture and wastewater systems. Steve Serfling is in charge of aquaculture operations and is confident that we will see the development of intensive shrimp production systems within the United States in the near future. The system Solar Aquafarms has developed incorporates greenhouse covers for environmental control, natural foods produced within the system, special habitat tanks to provide maximum use of the water volume, and water treatment areas (10%-20% of culture volume) for rejuvenation of the culture water. The cost of the system is greater than that of production ponds, but adds only 20¢ per pound of shrimp produced when amortized over 15 years. This is comparable to the facility costs for Coca-Cola's operations. Solar Aquafarms expects to produce 20,000 to 30,000 lbs/acre/year (heads on) with its system. Serfling is especially pleased with the recent success of spawning *P. vannamei* in captivity by his company as this species has historically been difficult to spawn.

According to Serfling, "one of the major problems is finding developing funds as there is no historic evidence

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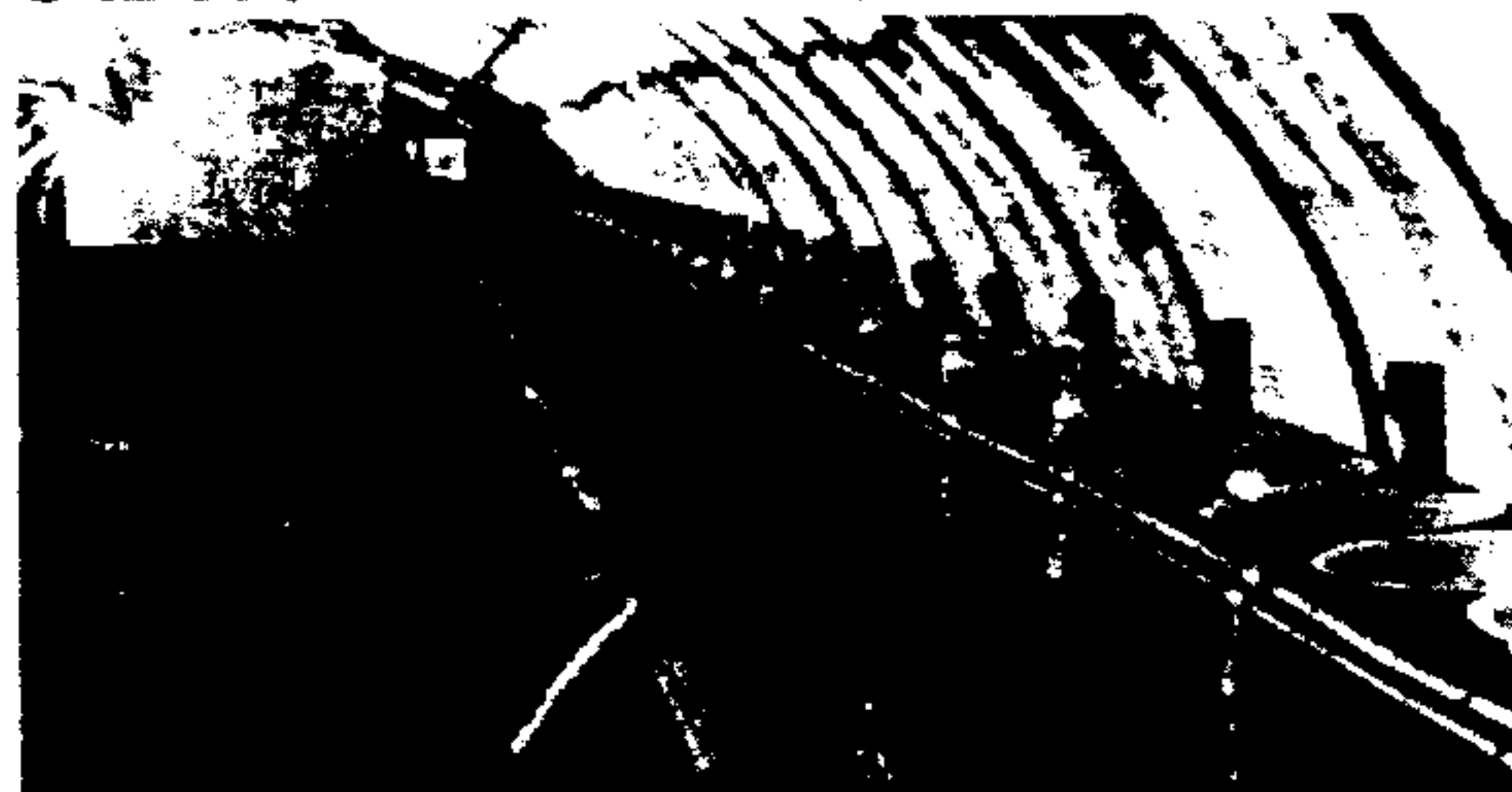
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that shrimp farming can be successful in the United States." This appears to be a recurring problem that can only be solved with some successful operations by companies with adequate risk money or by a government, pilot scale project.



GREENHOUSE FACILITY at Solar Aquafarms in California.

Serfling sees the slow development of shrimp culture in the United States, with major emphasis on intensive systems. "There should be no reason that we could not be self-sufficient in the production of shrimp for domestic use," he said.

#### Major Research Programs in Shrimp Culture

There are three main research organizations working on commercial shrimp culture in the United States: The National Marine Fisheries Service, at Galveston, Texas; Texas A&M University, at College Station, and Corpus Christi, Texas; and The Oceanic Institute, in Hawaii.



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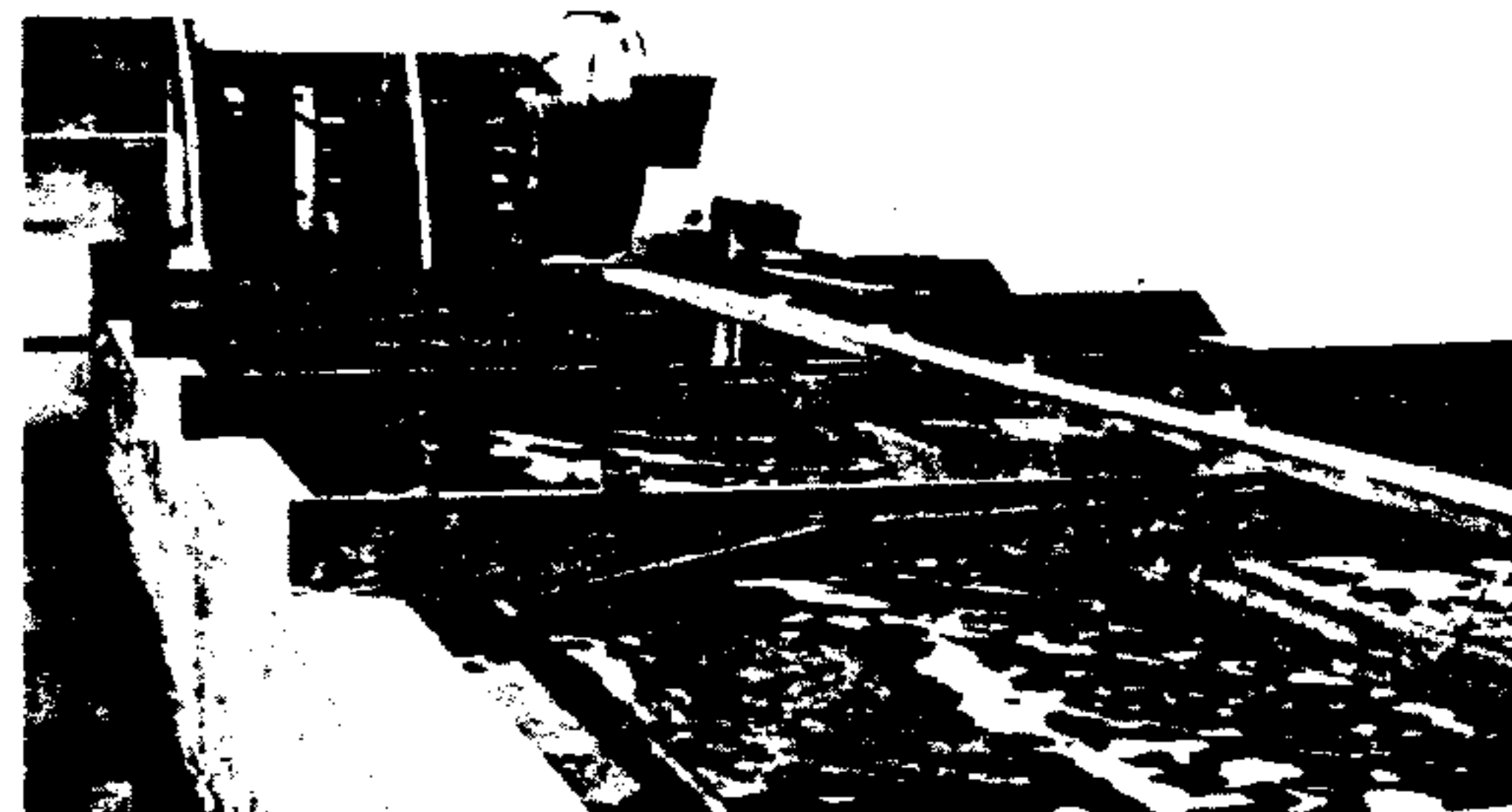
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Some smaller scale research programs exist at various state agencies and universities but 90% of the funding for shrimp research is concentrated in the three major programs. Total funding for all three programs is about \$1,000,000. This represents only about 1% of the total value of shrimp consumed in the United States each year and a smaller percentage of the total investment in shrimp production. Considering the complexity of the problems associated with shrimp culture, this is far short of the amount required to advance the industry properly.

#### National Marine Fisheries Service (Galveston)

The National Marine Fisheries Service at Galveston has been involved in shrimp research since 1968. It is recognized for its work on hatchery technology, maturation (reproduction), shrimp nutrition, and intensive culture of shrimp in closed systems. The facilities consist of a shrimp hatchery, controlled environment tanks for maturation of shrimp brood stock, raceway systems for testing various shrimp grow-out techniques and water treatment systems, nutrition laboratory, pathology laboratory, and chemistry laboratory. Dr. Edward F. Klim and Dr. James P. McVey are the main contact people for the Laboratory.



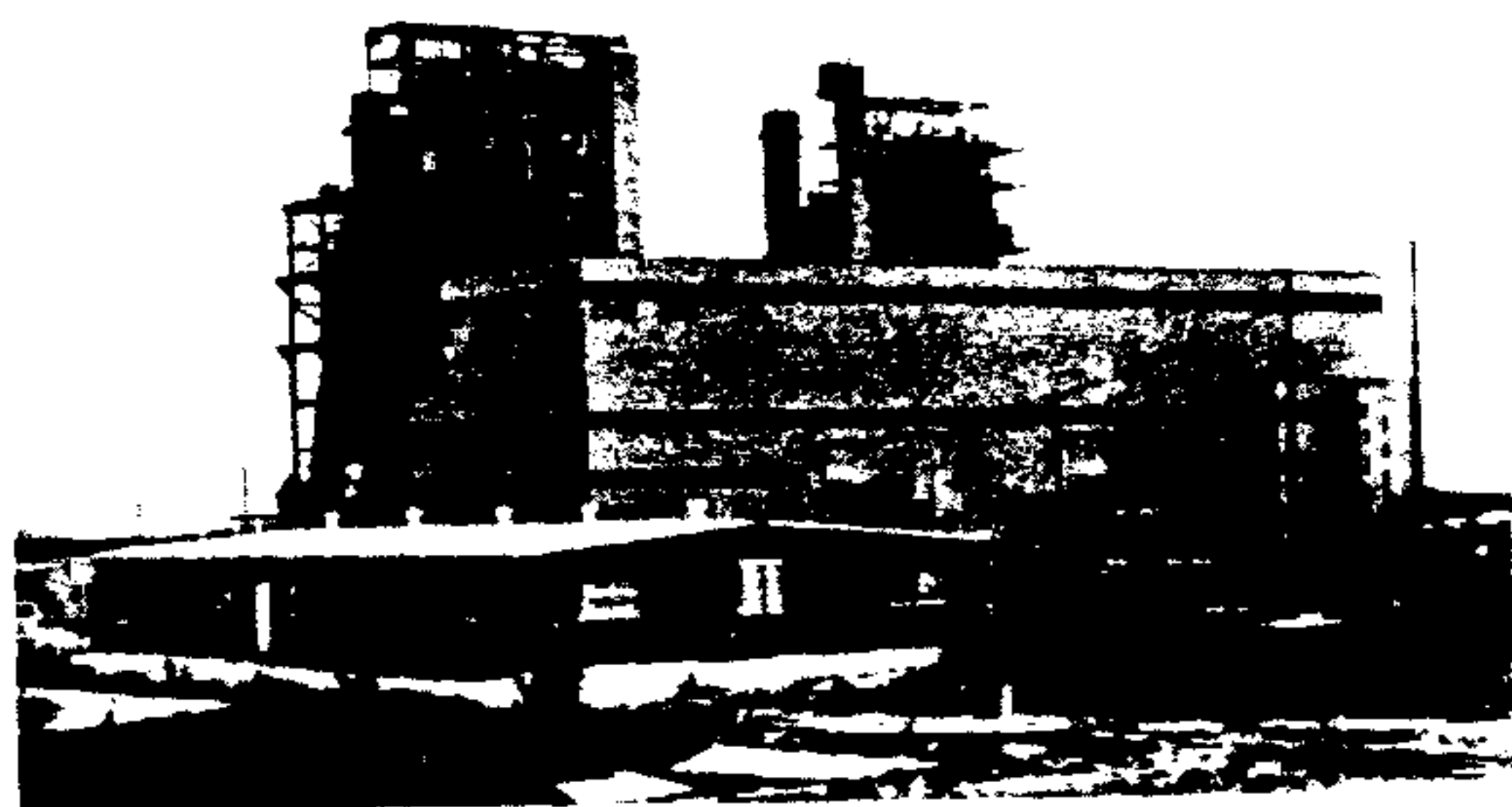
PROTOTYPE of closed-system intensive culture raceways for penaeid shrimp at NMFS, Galveston Laboratory, showing biodisc treatment system used to remove dissolved organics, and automatic feeding system.

Most commercial hatcheries in the shrimp culture industry have incorporated hatchery technology generated by National Marine Fisheries Service, Galveston. The most recent accomplishment has been the successful mating and spawning of *Penaeus stylirostris* in captivity. Work on captive reproduction is continuing with other species and the Laboratory has recently hired a geneticist to provide guidance in the selective breeding of the strains that are now being developed. The Laboratory maintains close working relationships with Texas A&M University and The Oceanic Institute to insure maximum coordination of the United States shrimp research programs.

#### Texas A&M University

Texas A&M University has a major research program that has concentrated on the pond culture of penaeid shrimp. The University has pond facilities at Angleton, and at Corpus Christi, Texas. A major research facility at Port Aransas, Texas has just been completed, providing 16 large tanks for experimentation in the reproduction of shrimp in captivity. Expertise also exists in pathology, nutrition, and the economics of shrimp farming.

Dr. Jack Parker is in charge of the pond research at Angleton and coordination of shrimp research at the main campus. Dr. Addison Lawrence is in charge of the maturation and pond facilities at Port Aransas and Corpus Christi, respectively. They expect Texas A&M University to play an important role in the development of shrimp aquaculture in Texas. At this moment there is considerable interest in developing shrimp farms around Brownsville and Port Isabel, Texas. Land has been purchased by some companies and ponds should be under construction in the near future.



NEW TEXAS A&M University Shrimp Maturation/Reproduction Facility located at Barney M. Davis Power Station (background)

### The Oceanic Institute

The aquaculture program at The Oceanic Institute, in Hawaii, headed by Dr. Robert Shleser, is a relatively new program in shrimp research. However, the Institute has developed two shrimp hatchery facilities (Galveston and Japanese technology), larval food production facilities, shrimp maturation facilities, and pond grow-out facilities. They are interested in developing techniques for extensive and intensive production of shrimp under Hawaiian conditions. The primary research thrust, however, will be to determine the mechanism of hormone control of shrimp reproduction.

### Future Outlook

The general feeling of those involved in the industry is one of guarded optimism. Many problems still confront the industry, and very little commercial development has actually taken place. New technological developments, i.e. improved diets, improved intensive culture systems, control of captive reproduction, better species, have had a positive effect on the development of the industry. Other factors favoring development of a shrimp aquaculture industry in the United States are the escalating cost of diesel fuel, the declining shrimp yield per boat effort, the high cost of importing shrimp, and the reduced volume of shrimp for the shrimp packing industry. As a result, many individuals and major companies are seriously considering investments in shrimp farming.

Most industry representatives feel that United States shrimp aquaculture could replace foreign imports and provide for the increased demand projected for the future, assuming that the domestic shrimp catch would remain at present levels. They believe the industry suffers from inadequate information concerning the economics of shrimp farming, and that one of the research requirements should be to provide realistic economic analyses based on pilot studies so that lending institutions had sufficient data to

evaluate loan requests.

Initial development in the United States will probably be on the lower Texas coast where coastal land can still be obtained for a reasonable cost and where the environmental conditions are favorable. Extensive pond culture will probably be the first development, with one crop per year production. Two crops per year may be possible if heated intensive culture raceways are used to headstart postlarval shrimp for early spring stocking. Some ponds in Central America obtain 2.8 crops per year, and improvements in intensive closed system culture could eventually provide this level of production in the United States.

### Action Required to Promote Shrimp Aquaculture

The most important action for promotion of shrimp aquaculture, or any other form of aquaculture, would be enactment of Federal legislation recognizing the importance of aquaculture in the United States. Such legislation would provide the basis for additional funding to bring about the rapid development of shrimp aquaculture. In addition, a master plan for research and development is needed. A National Aquaculture Plan is now in the process of being prepared by the Joint Subcommittee on Aquaculture. The section dealing with penaeid shrimp stresses the need for development of a national policy advocating aquaculture growth, simplification of permit procedures, and substantial research input to expand shrimp farming technology. Suggested administrative actions include the development of a coastal plan incorporating aquaculture within its priorities and the creation of a single permit office that would consolidate all permits. The plan states that research emphasis should be on domestication of a penaeid shrimp species and on the engineering of semi-closed systems to meet the requirements of United States culture conditions. Pathology and nutrition research were also identified as important to the improvement of commercial production.

The National Aquaculture Plan calls for a national marine-shrimp culture program to be created for development of a technical base for the industry. The proposed program would be a consortium of federal, state, university, and industry interests.

The most important part of the Plan is the realization that a long-term commitment to the development of a United States aquaculture industry is essential. Aquaculture, like agriculture, will take many decades to develop the technology, breeding strains, and infrastructure necessary for stable commercial development. According to the present industry representatives, most of the technology is now available for limited commercial success, but many refinements and additional production experience will be necessary to bring the industry to the point where yields can be predictable. Once there is predictability, the industry should have no trouble generating the financing which appears to be a major constraint at this time. □

*Editor's Note: Dr. McVey is Chief of the Aquaculture and Technology Division, National Marine Fisheries Service, Southeastern Fisheries Center, Galveston Laboratory, Galveston, Texas. He spent seven years in Micronesia developing the aquaculture program for the U.S. Trust Territory.*